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(Unlimited)

# Flying Personnel

# Research Committee

## The Retention of Protective Adaptation to Motion
## Sickness Induced by Cross - Coupled
## Angular Accelerations

by

J. T. Reason and E. Diaz

Department of Psychology

University of Leicester

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## ABSTRACT

Two experiments are reported. In the first, designed to assess the retention of adaptation to repeated exposures of graded cross-coupled angular accelerations, eight young men received eight adaptation sessions in alternate directions of rotation over a total period of 24 weeks. The results indicated a steady build-up of 'savings' of protective adaptation as reflected by the progressive reduction in stimulation required to achieve an operationally-defined level of adaptation. There was a corresponding decline over sessions in motion sickness symptomatology and loss of well-being. Of particular interest was the fact that adaptation acquired in one direction of rotation appeared to transfer to the opposite direction, as well as to subsequent sessions in the same direction. No systematic relationship was observed between the initial rate of adaptation on Session 1 and the subsequent degree of retention.

The second experiment examined the relationship between the 'savings' of adaptation on the second of two exposures and the time interval between them. Twenty-five young men were assigned to five equal groups matched for motion sickness history, the 1-day, 2-day, 7-day, 14-day and 21-day groups, where these times referred to the interval between the first and second exposures to the same graded cross-coupled stimulus. No decline in savings was observed with increasing time intervals the mean savings on Session II fluctuated around a value slightly in excess of 50 per cent, irrespective of the time elapsed since Session I. Finally, an attempt was made to integrate the findings of these two experiments into a general theoretical statement concerning the decay of protective adaptation following both single and repeated exposures to an adapting stimulus.

Motion sickness;                    cross-coupled angular accelerations;

retention of adaptation;           adaptation schedules;

prevention of motion sickness.

## INTRODUCTION

When healthy individuals are suddenly exposed to a rearranged
force environment of the kind encountered aboard a platform rotating
at, say, 6 to 10 rev/min, a very large proportion of them rapidly
become motion sick. However, if the same level of cross-coupled
stimulation is approached gradually via a series of small
step-increments in angular velocity, then little or no loss of
well-being results. Furthermore, the protective adaptation acquired
in this way appears to be retained long after the adapting stimulus
has been removed. Thus, individuals who have received a single
adapting exposure tend to show reduced susceptibility to motion
sickness when they subsequently encounter the same kind of atypical
force environment. These observations make it feasible to consider
the prior administration of 'adaptation schedules' in order to
minimise the incidence of motion sickness in astronauts and aircrew
when they eventually meet their respective flight conditions.
Theoretical considerations concerning the possible mechanisms
underlying this adaptation process have been discussed at length
elsewhere (Reason, 1970; Reason & Graybiel, 1972).

The early work in this area (Bergstedt, 1965; Reason & Graybiel,
1970: Reason & Diaz, 1970; Benson, Reason & Diaz, 1971) was primarily
concerned with specifying the optimal stimulus parameters of the
schedule so that the maximum degree of protection might be conferred
with the minimum cost in both time and discomfort. More recent studies
(Reason & Graybiel, 1972b) have been directed towards evaluating the
efficacy of these techniques, particularly with regard to the transfer
of adaptation from limited to generalised activities and from one
direction of rotation to the other, and also with the length of time
for which the acquired protection remains effective. Continuing in
this latter vein, the first of the two studies reported below sought
to assess the 'savings' in the amount of stimulation needed to achieve
adaptation in a group of subjects over a period of approximately six
months. It also examined the extent to which adaptation acquired in

one direction of rotation was effective when the subjects later
encountered the same stimulus in the opposite direction. The second
study, using five groups of subjects matched for motion sickness
history, was designed to investigate whether any systematic relation-
ship existed between the amount of 'savings' and the length of time
elapsing between two separate exposures to similarly graded cross-
coupled angular accelerations.

## EXPERIMENT ONE: METHOD

### Subjects

Eight male postgraduate students from the University of Leicester
served as subjects. Their ages ranged from 21 to 26. None had had
any previous experience of the rotating device.

### Apparatus

The subjects were seated in a cylindrical rotating compartment,
1.5 m in diameter, with their z-axes aligned with the axis of rotation.
A full description of the Leicester Rotating Device has been given
elsewhere (Reason & Diaz, 1970), but its principal features are shown
diagrammatically in Fig 1.

For this study, the interior of the device was illuminated and the
subject's field of view was restricted by heavy curtains drawn around
the inside periphery of the compartment. During rotation, the external
lights were turned off so that the subject was unable to derive any
visual cues as to his speed and direction of rotation. These visual
conditions were identical to the Internal Visual Reference (IVR) mode
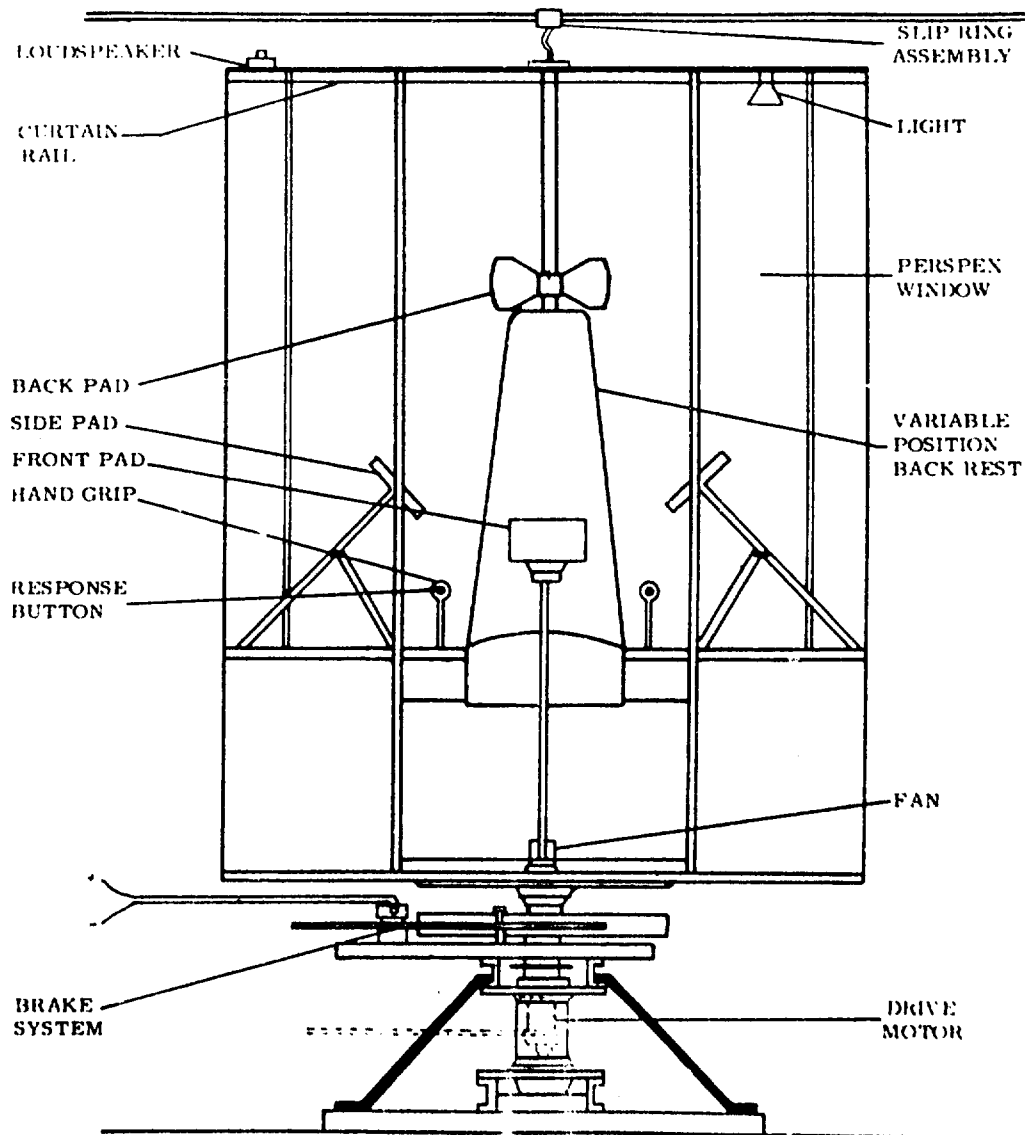discussed in an earlier experiment (Reason & Diaz, 1970).

LOUDSPEAKER

SLIP RING
ASSEMBLY

CURTAIN
RAIL

LIGHT

PERSPEX
WINDOW

BACK PAD

SIDE PAD

FRONT PAD

HAND GRIP

VARIABLE
POSITION
BACK REST

RESPONSE
BUTTON

FAN

BRAKE
SYSTEM

DRIVE
MOTOR

**Fig 1.** Diagram of rotating device (curtains
have been omitted for sake of clarity.)

## Procedure

Each subject received eight rotating sessions, four in the clock-wise (CW) and four in the counter-clockwise (CCW) direction, and the direction of rotation was alternated from one session to the next. The first four sessions were each separated by an interval of one week, then there was an interval of six weeks followed by two more sessions at one-week intervals. Then came a gap of 12 weeks followed by the two final sessions, again separated by an interval of one week.

The procedure in each session was essentially the same as that described for a previous study (Reason & Diaz, 1970). Briefly, each subject executed controlled head and body movements at each of five 1-rev/min increments in the angular velocity of the device; that is, rotation commenced at 1 rev/min and proceeded via a series of 1-rev/min step-increments up to a terminal velocity of 5 rev/min. The head movements were grouped into sequences of eight: four 'down' movements in each quadrant (front, back, left and right), and four 'return' movements to the upright position. With each movements, the head passed through an arc of 90°.

At the completion of each movement, the subjects made one of two possible responses: either 'Yes' meaning that they had detected some unusual sensations due to the Coriolis vestibular reaction (Guedry, 1965), or 'No' meaning that they were unaware of the cross-coupled angular stimulus; in other words, that the subjective feedback accompanying the head motion was identical to that experienced in a stationary environment. At each velocity step, the head movements were continued until each of 16 consecutive responses (2 complete sequences) was negative, and the subject was judged to be symptom-free. When this arbitrary adaptation criterion had been reached, the speed of the device was increased by 1 rev/min, and the procedure repeated until the adaptation criterion at the terminal velocity of 5 rev/min had been attained. At this point, the device was brought slowly to a halt, and the subjects were required to continue the same head motions until the post-run adaptation criterion had been reached.

Measures

The principal measure of adaptation was the total number of sequences executed prior to the adaptation criterion at the terminal velocity (5 rev/min). This included all the sequences, at all velocity steps, in which an affirmative response had been elicited, and provided an index of the amount of stimulation required to neutralise the subjective components of the Coriolis vestibular reaction.

The Well-Being Scale (Reason & Graybiel, 1970b) was used to measure per-rotational discomfort. This was a numerical index of well-being based on a scale from 0 ('I feel fine') to 10 ('I feel awful, just like I'm about to vomit'). These ratings were given verbally at the end of each sequence of head movements, and so provided a continuous indication of the subject's overall state of well-being.

In addition, at the end of each rotational session, the subjects were given a Symptom Score based on the extent and severity of the motion sickness reactions experienced during and immediately after the run. A full description of the way in which the Symptom Score is arrived at has been given elsewhere (Reason & Diaz, 1971).

## EXPERIMENT ONE: RESULTS AND DISCUSSION

The discussion of results will be in two parts: the first deals with the group data and their implications; the second with individual differences in the retention of adaptation. This division is convenient because these two aspects of the results appear to have distinct practical consequences. First, with regard to the prevention of motion sickness, we need to know for how long the protection conferred by an adaptation schedule remains effective for the average individual. Second, with regard to the prediction of individual susceptibility, we need to know how individuals differ in the extent to which they retain protective adaptation.
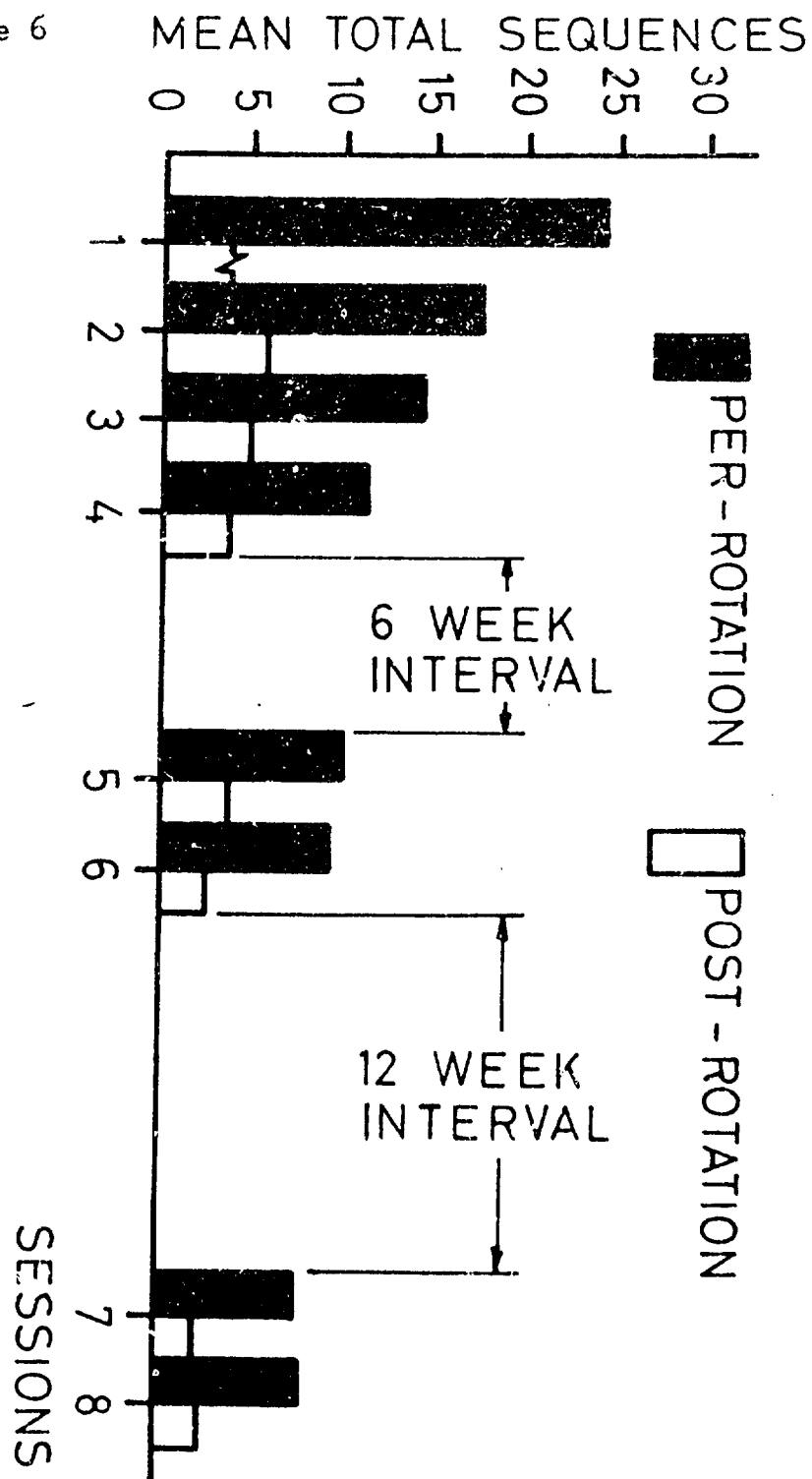
Fig 2.

Mean total sequences (N 8) executed prior to the adaptation
criterion at 5 rev/min on eight test sessions.

Group Data

(1) Adaptation to Cross-Coupled Angular Accelerations

Fig 2 shows the mean total number of sequences required to attain
the adaptation criterion at 5 rev/min for each of the rotational
sessions. Table 1 shows the percentage 'savings' in the mean total
number of sequences on Session 2-8 as compared with Session 1.

Table 1

Percentage 'Savings' in Stimulus Exposure to Adaptation over Sessions 2-8

| Session Number | Time after first exposure (weeks) | Percentage of savings in sequences to adaptation criterion (re: Session 1) |
|---|---|---|
| 2 | 1 | 30 |
| 3 | 2 | 43 |
| 4 | 3 | 55 |
| 5 | 9 | 60 |
| 6 | 10 | 63 |
| 7 | 22 | 70 |
| 8 | 23 | 69 |

With repeated exposures to the adapting stimulus, it can be seen
that there was a steady decline in the number of head movements
required to neutralise the subjective components of the Coriolis
vestibular reaction, at least up to Session 8. As indicated in
Table 1, the same data may be expressed in a different way: in terms
of the percentage of savings in required stimulation relative to the
initial exposure. This increased from session to session in a
negatively accelerated fashion, apparently reaching asymptote in

Session 7. It seems reasonable to assume that these increases in
savings reflected the developing strength of the protective adaptation
as it was retained and further consolidated from one session to the
next.

Going beyond this general statement of our group adaptation
results, there were two findings of particular interest which promise
to have important practical and theoretical implications. The first
was that no spontaneous remission of adaptation resulted from either
the six-week or the twelve-week periods without exposure to the
adapting stimulus. On the contrary, there was actually some increase
in savings following these two lengthy intervals - a phenomenon which
appeared to have something in common with the reminiscence effects
reported in early memory studies (Woodworth & Schlosberg, 1954). Be
that as it may, the first four sessions were clearly sufficient to
induce a relatively enduring degree of adaptation which, with the two
'top-up' sessions after six weeks, remained intact for both
directions of rotation over a total period exceeding five months. We
have no information regarding its retention beyond this point, but it
seems highly probable that it would take a very long time, if at all,
for these subjects to return to their initial state of susceptibility.
This finding, in particular, suggests the potential of adaptation
schedules for both the prevention of motion sickness, and its reduction
in long-standing cases (see Dobie, 1974).

The second finding of interest was the extent to which adaptation
appeared to transfer to the opposite direction of rotation. This was
especially noticeable in Session 2 in which there was a 30 per cent
saving in sequences relative to Session 1, and in which there had been
no prior experience of that particular direction of rotation. However,
the same tendency was present to a lesser degree throughout: with the
exception of Session 8, the sequences needed to attain the adaptation
criterion on each session were always fewer than those required for
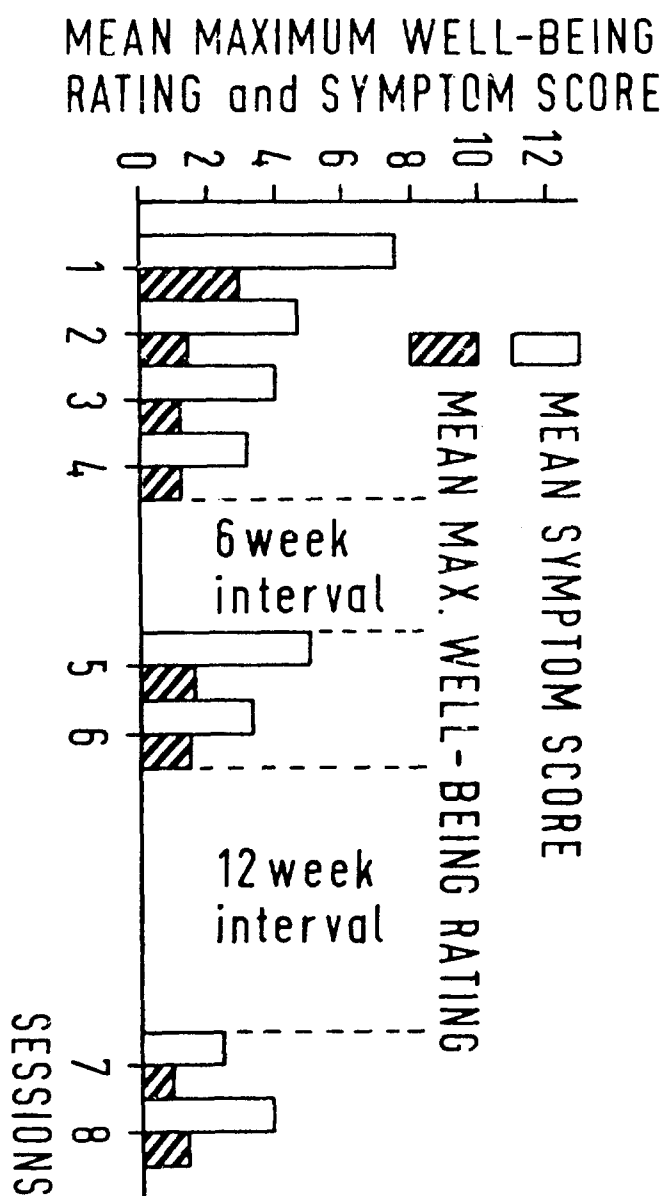the preceding session in the opposite direction of rotation. Thus, by

Fig 3. Mean maximum well-being rating and Symptom Score on the eight test sessions.

alternating the direction of rotation of the adapting sessions, it
appears possible to provide a generalised protection which remains
effective for both directions over long periods of time.

## (2) Motion Sickness Reactions and Well-Being Ratings

Fig 3 shows the mean Symptom Score and the mean maximum Well-Being
Ratings for each of the eight rotational sessions. Both of these indices
were such that the higher their values, the greater was the degree of
disturbance.

The motion sickness reactions observed in this study never
exceeded the Malaise III level of severity (Graybiel, 1968); that is,
subjects never went beyond the experience of nausea to the point of
vomiting. Over the first four sessions, indications of motion
sickness diminished in much the same way as the number of sequences
needed to attain the adaptation criterion. Up to Session 4, therefore,
the absence of subjective Coriolis phenomena appeared to be closely
linked with reduced susceptibility to the nauseogenic stimulus.
However, immediately after the 6-week interval, there was clearly some
reduction in the level of protection against motion sickness, while
the same remission did not occur for the illusory sensations of
motion accompanying the head movements. Increases in the Symptom Score
on Session 5 (relative to Session 4) occurred in 5 out of the 8
subjects, but only in one case was this increase of any magnitude.
Although these differences between the degree of apparent adaptation
to the subjective Coriolis phenomena and that to motion sickness were
small, they suggest the need for caution in using the presence or
absence of illusory sensations as an index of motion sickness
protection. For most situations, this relationship between protection
and the subjective phenomena appears to hold good; but exceptions do
arise as shown by the present data.

Curiously enough, the same spontaneous loss of motion sickness
protection did not occur on Session 7 following the 12-week interval.

But, on Session 8, 5 of the subjects showed increases in motion sick-
ness reactions, suggesting some loss of protection relative to
Session 7. In all cases, however, these increases were comparatively
slight.

## Individual Differences

The individual patterns of 'savings' in per-rotational sequences
to criterion shown in Fig 4 reveal no systematic relationship between
the initial level of adaptability on Session 1 and the subsequent reten-
tion of adaptation. A previous study (Reason & Graybiel, 1972) has
shown that rates of adaptability assessed in a single session are
positively and significantly correlated with both motion sickness
history and the degree of per-rotational symptomatology. But, from
the present data, it is clear that if we want to make predictions
concerning an individual's future susceptibility to, say, airsickness
on the basis of his adaptive capacity, we need to know not only the
characteristic rate at which he first acquires adaptation, but also
the extent to which this protection is retained with the passing of
time.

Judging from the present results, an accurate assessment of this
important characteristic of retentiveness would require a minimum of
three repeated adapting sessions. Previous research (Reason &
Graybiel, 1972) indicates that a reliable measure of individual
adaptability on a single session can be obtained very quickly at
angular velocities up to 3 rev/min. Our present estimate, therefore,
is that three adapting sessions, each to 3 rev/min and each separated
by about 24 hours would provide an adequate measure of retentiveness.
From normative data collected previously, it is likely that the total
testing time for all three sessions would not exceed an hour and a
half; 50 per cent of the normative sample (N=70) attained the adaptation
criterion at 3 rev/min in 5 sequences (40 head movements or less
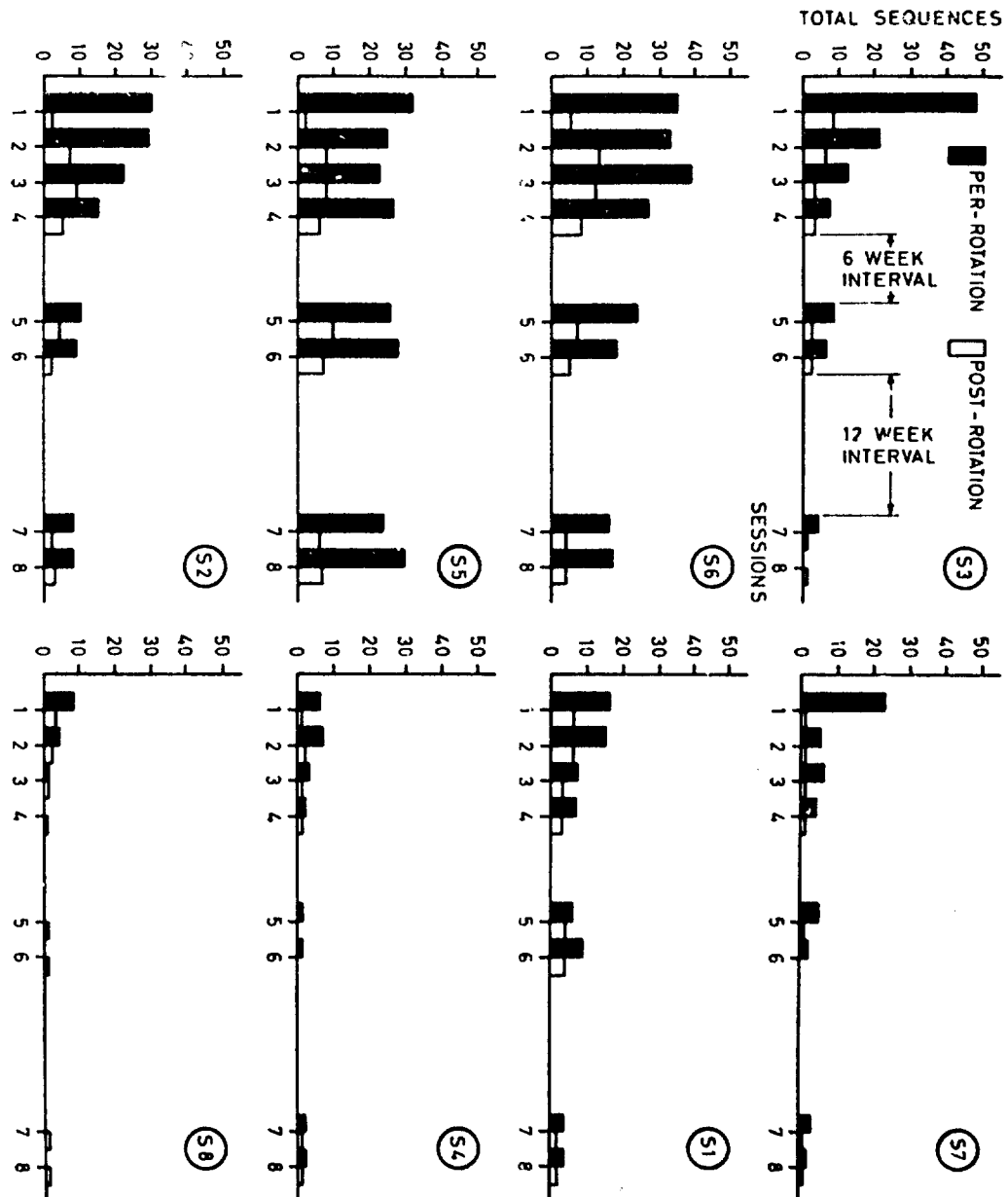(see Reason & Graybiel, 1972)).

Fig 4.

Individual pattern of initial adaptability and subsequent retention of adaptation.

## EXPERIMENT TWO: METHOD

Twenty-five male subjects, drawn from the same population as those above, were used as subjects. None had had any previous experience of the rotating device. After completing the Motion Sickness Questionnaire (Reason, 1968), the subjects were assigned to five equal groups that were approximately matched with regard to motion sickness history (Mean MSQ scores for the groups: 30, 29, 30, 29, and 31).

Each group was exposed to two rotational sessions in the Leicester Rotating Device, all sessions being in the CW direction of rotation. The basic procedure during each session was the same as that described for Experiment 1. The major difference between the two experiments was that each subject received only two exposures to the cross-coupled stimulus (both being in the same direction), but the time interval between them varied from group to group. Thus, the five groups can be labelled as follows: 1-day group, 2-day group, 7-day group, 14-day group and 21-day group, where all the subjects in any one group had the stated interval between the two sessions. The measures were the same as those in Experiment 1, namely, the total number of head movement sequences executed prior to the adaptation criterion at the terminal velocity of 5 rev/min, Well-Being Ratings recorded at the end of each sequence, and a Symptom Score computed at the end of each session.

## EXPERIMENT TWO: RESULTS AND DISCUSSION

The results for Experiment 2 are shown in Table 2. Table 3 indicates the mean percentage of savings for each group in the total number of sequences on Session II relative to Session I. Table 4 summarises a covariance analysis for the total number of sequences data.

## Table 2

### Summary of Results for Experiment 2

| | Total no. of sequences prior to adaptation at 5 rev/min | | Maximum Well-Being Rating | | Symptom Score | |
|---|---|---|---|---|---|---|
| | I* | II* | I | II | I | II |
| **1 DAY GROUP** | 27 | 12 | 5 | 4 | 14 | 4 |
| | 90 | 30 | 4 | 5 | 10 | 16 |
| | 35 | 23 | 3 | 4 | 4 | 2 |
| | 9 | 4 | 2 | 3 | 4 | 3 |
| | 36 | 11 | 3 | 2 | 1 | 1 |
| $\bar{x}$ | 39.4 | 16.0 | 3.4 | 3.6 | 6.6 | 5.2 |
| **2 DAY GROUP** | 48 | 34 | 4 | 2 | 6 | 3 |
| | 50 | 29 | 6 | 5 | 13 | 11 |
| | 26 | 16 | 7 | 8 | 11 | 10 |
| | 18 | 4 | 4 | 4 | 12 | 5 |
| | 23 | 5 | 3 | 0 | 4 | 0 |
| $\bar{x}$ | 33.0 | 17.6 | 4.8 | 3.8 | 9.2 | 5.8 |
| **7 DAY GROUP** | 16 | 8 | 5 | 4 | 7 | 9 |
| | 26 | 22 | 5 | 2 | 11 | 5 |
| | 9 | 11 | 4 | 0 | 0 | 0 |
| | 42 | 15 | 5 | 2 | 3 | 1 |
| | 26 | 12 | 0 | 0 | 3 | 6 |
| $\bar{x}$ | 23.8 | 13.6 | 3.8 | 1.6 | 4.8 | 4.2 |
| **14 DAY GROUP** | ? | 0 | 0 | 0 | 0 | 0 |
| | 8 | 7 | 2 | 0 | 5 | 1 |
| | 48 | 12 | 6 | 0 | 10 | 1 |
| | 36 | 9 | 8 | 9 | 16 | 6 |
| | 17 | 6 | 0 | 1 | 1 | 1 |
| $\bar{x}$ | 22.2 | 6.8 | 3.2 | 2.0 | 6.4 | 1.8 |
| **21 DAY GROUP** | 46 | 20 | 5 | 5 | 11 | 12 |
| | 43 | 28 | 5 | 2 | 14 | 2 |
| | 8 | 6 | 1 | 1 | 0 | 1 |
| | 7 | 2 | 0 | 0 | 0 | 0 |
| | 8 | 4 | 0 | 1 | 2 | 2 |
| $\bar{x}$ | 22.4 | 12.0 | 2.2 | 1.8 | 5.4 | 3.4 |

* I and II indicate first and second rotational sessions

Table 3

Mean Percentage of Savings in Total Number of Sequences Executed in Session II

| Groups | Mean percentage of savings (re: Session I) |
|--------|--------------------------------------------|
| 1 day  | 59.4 |
| 2 days | 46.7 |
| 7 days | 42.8 |
| 14 days | 69.4 |
| 21 days | 46.4 |

Inspection of Table 2 shows that, with one exception (in the 7-day group) all the subjects required fewer head movement sequences to reach the adaptation criterion at 5 rev/min in Session II than they did in Session I. Although slightly less consistent, the same pattern of reduction in Session II also held for motion sickness susceptibility as indicated by the Well-Being Ratings and Symptom Scores. From these data it is clear that a substantial proportion of the protective adaptation acquired in Session I was still intact during Session II. This finding was consistent with earlier observations (Reason & Diaz, 1970; Reason & Graybiel, 1972).

Table 4

Summary of Covariance Analysis Sequences Data

| Source | Sum of Squares | df | Mean Square | F |
|--------|----------------|----|-------------|----|
| Time intervals | 154.89 | 4 | 38.72 | 1.11 (Not significant) |
| Error | 661.91 | 19 | | |
| | 816.80 | 23 | | |

More surprising, however, was the fact that there was no
appreciable decline in this retention of protective adaptation as the
interval between the two exposures was increased. The mean savings
on Session II appeared to fluctuate around a value slightly in excess
of 50 per cent, irrespective of the time interval (see Table 3).
In addition, the analysis of covariance (see Table 4) yielded a
non-significant F ratio. A possible explanation for these results
is given below.

### THEORETICAL CONSIDERATIONS

Taken together, Experiments 1 and 2 provide us with some clues as
to the way in which the level of protective adaptation falls following
the cessation of an adapting stimulus. In this section, we will
attempt to integrate the findings of both experiments into a general
theoretical statement concerning the rate of decay of protective
adaptation following both single and repeated exposures to an
adapting stimulus.

In Experiment 2, our failure to demonstrate any decline in
protective adaptation with increasing time after the first exposure
would make sense if it were assumed that adaptation decays in an
approximately exponential fashion with the most rapid rate of decline
occurring immediately after the end of the first exposure; and where
the rate of decay levels out subsequently to some intermediate value.
If this were so, then the results of the second experiment could be
explained by suggesting that our range of time intervals, from 1 to 21
days, was such that it only allowed us to sample this relatively stable
level of retained adaptation. This argument has been expressed
diagrammatically in Fig 5.

Indirect evidence to support this notion of an initially rapid
rate of decay comes from a three-day adaptation study in the Pensacola
Slow Rotation Room where subjects on a predetermined schedule were
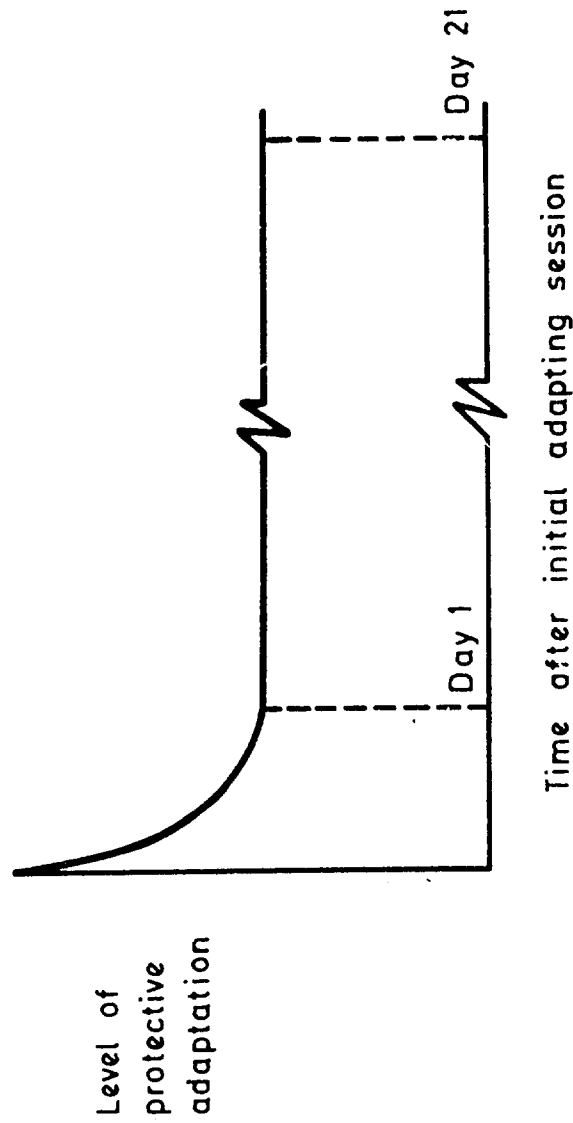required to continue making controlled head movements well beyond the

Fig 5. Suggested rate of decay of protective adaptation following a single adapting exposure. The dotted lines indicate the range of time intervals used in the present experiment.

adaptation criterion at each velocity step (Reason & Graybiel, 1977b).
It was observed that short rest periods of 5 to 10 minutes, where the
head was immobilised, frequently resulted in the reinstatement of the
Coriolis subjective phenomena during the first few sequences after
the pause.  In other words, even these very short intervals of
inactivity were sufficient to cause a marked loss of protective
adaptation - despite the fact that they had been preceded by a large
number of adapting head movements.  This loss of adaptation was even
more apparent after a night spent resting and sleeping at the same
rotational speed.  When the head movements were resumed the next
morning at the same angular velocity, several sequences were required
before the subjective phenomena were once again neutralised.

The design of Experiment 1, although complicated by alternating
directions of rotation, allowed us to examine the retention of
adaptation following repeated exposures to the same stimulus.  From
the data shown in Fig 2, particularly the rate at which the number
of sequences to criterion declined with each repetition of the
adapting stimulus, it can be argued that the rate of adaptation decay
decreases as a function of the number of preceding exposures.  More
precisely, we can hypothesise that the time-constant of adaptation
decay following a given exposure increases with the number of
exposures that preceded it, as shown diagrammatically in Fig 6.

Although we only have slight evidence for this, it is also
likely that the time-constant of adaptation decay increases in a
negatively accelerating fashion with repeated exposures, as shown in
Fig 7.  Put in another way, this means that although the amount of
protection measured at some point following the last exposure increases
with the number of preceding exposures, it is unlikely that it will
ever remain permanently at the 100 per cent level.  In other words,
there is always likely to be some loss of adaptation, albeit very
small, no matter how many times an individual has been exposed to the
adapting stimulus.  However, it should not be assumed that 100 per cent
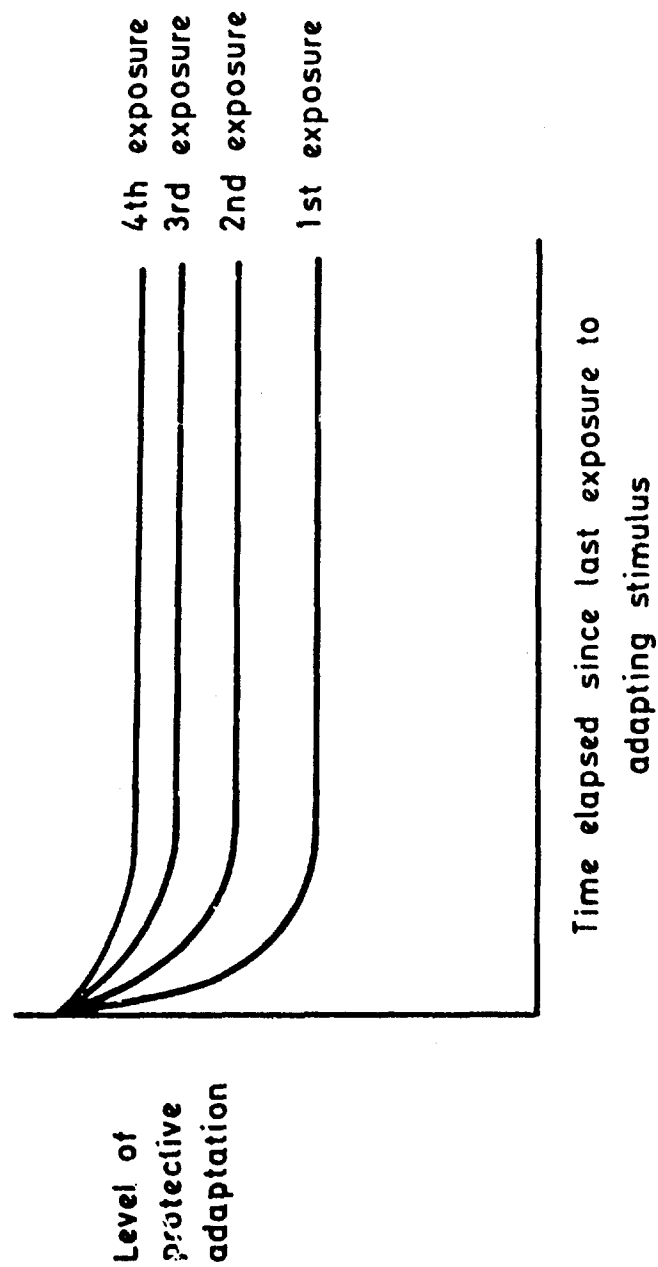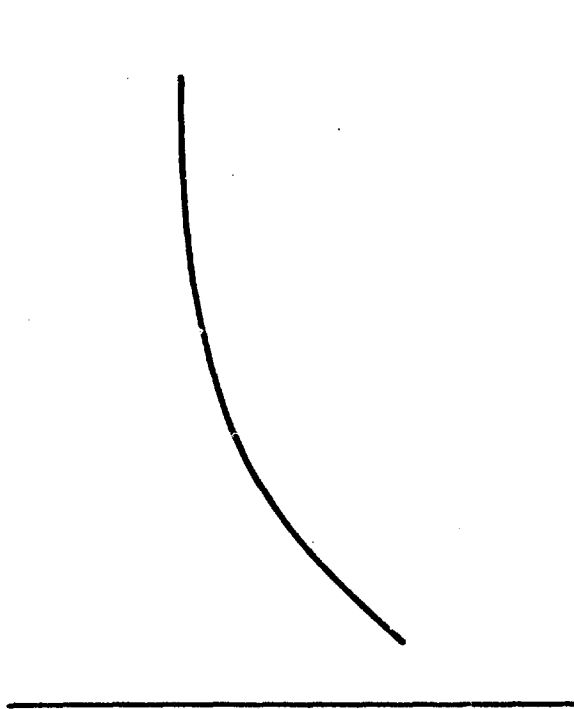savings with regard to the Coriolis subjective phenomena is necessary

Fig 6. Some speculations regarding the rate of decay of protective adaptation following repeated exposures to the adapting situation.

Time – constant of adaptation decay following last exposure

Number of adapting exposures

*Fig 7.* Further speculations regarding the relationship between the time-constant of adaptation decay and the number of previous exposures to the adapting stimulus.

to guarantee protection against motion sickness. It is clear from the many previous investigations in this area that a moderate degree of these Coriolis phenomena can be tolerated without risk of associated symptoms.

Though speculative, these theorectical considerations are open to empirical test. However, even if the rate of decay of protective adaptation is far more complex than indicated above, the findings of these two studies augur well for the prophylactic value of adaptation schedules.

## REFERENCES

BENSON, A.J., REASON, J.T. & DIAZ, E. (1971). Testing Predictions
Derived from a Model of Progressive Adaptation to
Coriolis Accelerations. Flying Personnel Research
Committee Report No 1311.

BERGSTEDT, M. (1965). Stepwise adaptation to a velocity of 10 rpm
in the Pensacola Slow Rotation Room. In: The Role of
the Vestibular Organs in the Exploration of Space.
NASA SP - 77. Washington D.C.: U.S. Government
Printing Office.

DOBIE, T.G. (1974). Airsickness in Aircrew ARGARDOGRAPH No 177
London Technical Editing and Reproduction Ltd.

GRAYBIEL, A. (1969). Structural elements in the concept of motion
sickness. Aerospace Med., 40 : 351-367.

GUEDRY, F.E. (1965). Psychophysiological studies of vestibular function.
In: Contributions to Sensory Physiology, ed. W. D. Neff.
New York: Academic Press.

REASON, J.T. (1968). An Investigation of Some Factors Contributing to
Individual Variation in Motion Sickness Susceptibility.
Flying Personnel Research Committee Report No 1277.

REASON, J.T. (1970). Motion sickness: a special case of sensory
rearrangement. Advancement of Science, 26 : 386-393.

REASON, J.T. & DIAZ, E. (1970). The Effects of Visual Reference on
Adaptation to Coriolis Accelerations. Flying Personnel
Research Committee Report No 1303.

REASON, J.T. & DIAZ, E. (1971). Simulator Sickness in Passive Observers.
Flying Personnel Research Committee Report No 1310.

REASON, J.T. & GRAYBIEL, A. (1969). Adaptation to Coriolis Accelerations:
its Transfer to Opposite Direction of Rotation as a
Function of Intervening Activity at Zero Velocity. NAMI
Report No 1085. Naval Aerospace Medical Institute,
Pensacola, Fla.

REASON, J.T. & GRAYBIEL, A. (1970). Progressive adaptation to Coriolis
accelerations associated with 1-rpm increments in the
velocity of the Slow Rotation Room. Aerospace Med., 41 :
73-79.

REASON, T.T. & GRAYBIEL, A. (1970b). Changes in subjective estimates
of well-being during the onset and remission of motion
sickness symptomatology in the Slow Rotation Room.
Aerospace Med., 41 : 166-171.

Author(s)

REASON J T
DIAZ E

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Title. THE RETENTION OF PROTECTIVE ADAPTATION TO MOTION SICKNESS INDUCED BY CROSS-COUPLED ANGULAR ACCELERATIONS

Abstract.

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The second experiment examined the relationship between the 'savings' of adaptation on the second of two exposures and the time interval between them. Twenty-five young men were assigned to five equal groups matched for motion sickness history: the 1-day, 2-day, 7-day, 14-day and 21-day groups, where these times referred to the interval between the first and second exposures to the same graded cross-coupled stimulus.

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